Center Innovation Fund: KSC CIF

Low Temperature Shape Memory Alloys for Adaptive, Autonomous Systems (SMA)

Completed Technology Project (2014 - 2015)

Project Introduction

The objective of this joint activity between Kennedy Space Center (KSC) and Glenn Research Center (GRC) is to develop and evaluate the applicability of 2-way SMAs in proof-of-concept, low-temperature adaptive autonomous systems. As part of this low technology readiness (TRL) activity, we will develop and train low-temperature novel, 2-way shape memory alloys (SMAs) with actuation temperatures ranging from 0°C to -150 °C. These experimental alloys will also be preliminary tested to evaluate their performance parameters and transformation (actuation) temperatures in low- temperature or cryogenic adaptive proof-of-concept systems. The challenge will be in the development, design, and training of the alloys for 2-way actuation at those temperatures.

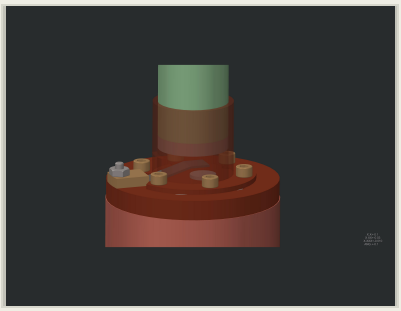
The feasibility of using SMAs to provide switchable thermal systems has been previously demonstrated by taking advantage of the 1- or 2-way actuation properties of SMAs, allowing a system to switch between a thermally insulative to a conductive state by actuation of the SMA at a preset temperature. However, the alloys designed or commercially available and tested to date had actuation temperatures above room temperature (65–95 °C). Technology needs still exists for autonomous actuation at cryogenic temperatures. The GRC portion of the research work is being leveraged to address such technology gaps in low-temperature SMA compositions and covers a broad chemistry of binary, ternary and quaternary alloys with temperature-induced actuation capabilities below 0 °C. Experimental alloys with elemental constituents encompassing Fe, Co, Cr, Hf, Cu and Zr added to the base NiTi alloy are explored and downselected. The new alloys are cryogenic trained for 2-way actuation for potential utilization in novel designs developed by KSC.

Anticipated Benefits

Significant benefit will be gained in expanding the knowledge base and novel innovation at multiple NASA centers in low-temperature SMA technologies. KSC's efforts focus on *SMA Adaptive Materials Systems Concepts and Designs* and GRC's efforts focus on *Novel Low-temperature Alloy Designs*. 2-way cryogenic temperature SMAs open new areas of applications in space and commercial aerospace (e.g. adaptive umbilical connectors (thermal and mechanical) which use surrounding environments to add multi-functionality). It is expected systems like this would allow for more robust operations in cryogenic storage and transfer systems and in-situ resource utilization for space exploration. It is expected technology success could result in game changing results for use of low temperature SMAs in adaptive, smart thermal/mechanical systems.

Aligns with the following NASA Strategic Initiatives:

-Strategic Space Technology Investment Plan (SSTIP) Strategic Goal 3:



Cryogenic training apparatus design for low temperature, two-way shape memory alloys

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technology investment framework under core technology investment and adjacent technologies, light weight structures and autonomous control, and surface systems.

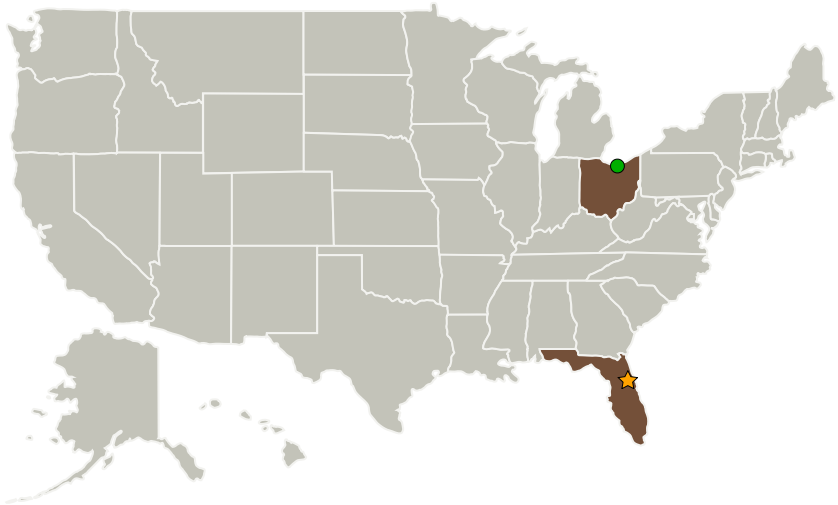
- NASA Roadmap technologies areas (TA) alignment TA12.2.1.4 Environment; TA12.2.2.1 Lightweight Concepts, Shape Morphing Materials; TA12.2.2.5 Innovative, Multi-functional Concepts, Adaptive/smart Structures; TA14.2.1 Cryogenic Systems; TA2.2.1.2 In-Space Propulsion, Liquid Cryogenic; TA2:2.4.2 Propellant Storage & Transfer; and TA13:1.1 Distribution, Storage and Conservation of Fluids.

-NASA Space Technology Grand Challenges – Space Colonization

Development of this technology also aligns with the Office of Science and Technology Policy (OSTP) focus area: Development of New Foundational Technologies to Reduce Future Costs Across NASA, Expand Opportunities, and Grow the American Economy.

Advancing development and NASA intellectual property in the area of multifunctional materials for cryogenic thermal control, autonomous systems, and technologies for umbilical and surface systems can result in technology transfer and benefits to the commercial space industry.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Kennedy Space Center (KSC)

Responsible Program:

Center Innovation Fund: KSC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Barbara L Brown

Project Manager:

Martha K Williams

Principal Investigator:

Martha K Williams

Co-Investigators:

James E Fesmire
Othmane Benafan

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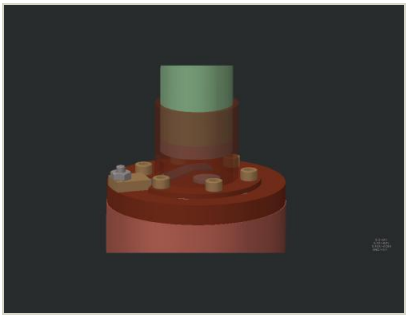
Organizations Performing Work	Role	Type	Location
★Kennedy Space Center(KSC)	Lead Organization	NASA Center	Kennedy Space Center, Florida
●Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Co-Funding Partners	Type	Location
University of Central Florida(UCF)	Academia	Orlando, Florida
University of Florida	Academia	Gainesville, Florida

Primary U.S. Work Locations	
Florida	Ohio

Images

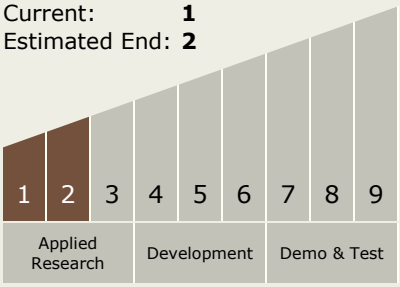


Cryogenic training apparatus design for low-temperature, two-way shape memory alloys

Cryogenic training apparatus design for low temperature, two-way shape memory alloys *(https://techport.nasa.gov/image/4063)*

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.8 Smart Materials

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Links

KSC-13955
(no url provided)